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No. VII.

THE following is an abstract of the paper read by Professor Harrison on the 26th of January, 1846. (*See page 184*).

It is generally known that Baron Cuvier, in the "Regne Animale," mentions two distinct species of Cassowary, one, the Galeated, or the *Struthio Casouarius*, found in several of the islands of the Indian Archipelago; the other, the *Casouarius* (or *Dromaius*) *Nova Hollandiae*.

The first, or galeated cassowary, has the bill compressed laterally, the head surmounted with a bony prominence, covered with a corneous substance; the skin of the head and top of the neck naked, tinted with a sky-blue and flame colour, with pendant caruncles, like those of the turkey; the wings have stiff feathers, without barbs, and serve as weapons in fighting; the claw of the internal toe is much the strongest. Next to the ostrich, this is the largest bird in nature, from which, however, it differs in internal organization, the intestines being short, and the cæca and cloaca small, and no intermediate stomach between the crop and gizzard; it lives on fruit and eggs, but not on grain. Its eggs are of a green colour. The second, or New Holland cassowary, has the bill depressed, no helmet on the head, naked round the ear only; the plumage is brown, thicker, and more bearded; no caruncles or alar spines, and the claws are nearly equal. On its internal organization the Baron makes no remark, neither does he allude to the peculiar condition of the trachea, which forms a striking discriminating character between it and the galeated bird. Dr. Knox, the distinguished anatomist and lecturer in Edinburgh, in an extremely interesting paper,

read before the Wernerian Natural History Society, and published in the Edinburgh Philosophical Journal, in April, 1823, has entered more fully into a comparison of the internal organization of these two species, and has given the first account I have met with, of the remarkable tracheal sac in the emu. His anatomical description, however, of this curious appendix, is brief and imperfect, which may be accounted for by the specimen he examined being greatly mutilated before it fell into his possession. His account of it is as follows:—"At the fifty-second ring, counting from the glottis, there is found a large muscular bag, about the size of a man's head, into which the windpipe opens by a large orifice, occasioned by a deficiency of part of the circumference, in about thirteen tracheal rings; or rather the rings, instead of closing round to form the tube of the trachea, expand outwards, and are attached to the sides of the bag; it has no communication with any of the air cells"—p. 36. "This muscular bag is as large as the human head, is closely attached to the sides of the trachea and expanded rings, is situated in the neck, immediately above the bone called the merrythought; it was seen by me in the female, though it is probable the male also possesses it. It is quite peculiar to this bird, no such appendage having been ever seen attached to the trachea of any of the feathered creation, nor do I know of anything analogous to it in any other animal, excepting in the chameleon, to the upper portion of whose trachea there is appended a comparatively large membranous bag."—p. 138. "It has not the most distant resemblance to the tracheal appendages found in other birds. In thus differing so singularly and mysteriously from the analogous structure of birds of the old and new continents, it fully confirms the opinions of some naturalists, that the living productions of Australia will, when properly examined, be found to present peculiarities altogether wonderful, and, perhaps, yet, for a long period, quite inexplicable."—p. 139.

Meckel, in the tenth volume of his Comparative Anatomy, alluded to the discovery of this air sac by Fremery, in the year 1819, but states that he has noticed it in a vague and imperfect manner. I have not had an opportunity of consulting this work of Fremery. Meckel does not describe this air sac with that clearness and precision so characteristic of this writer. His account rather consists of quotations from Knox, and of the varying statements of other writers, than of any observations of his own. Carus, in his System of Comparative Anatomy, makes no mention of it. It does not appear to have been known to Cuvier, as there is no notice of it either in his Anatomie Comparée, or in his Regne Animale, neither is it alluded to in the new edition of that invaluable work, now in course of publication. In the elaborate and excellent article "Aves," in the Encyclopædia of Anatomy and Physiology, edited by Dr. Todd, of London, and which article is from the pen of Mr. Owen, who is justly regarded as the first comparative anatomist and zoologist of the present day, this peculiar appendage is alluded to; but, strange to say, the brief and imperfect account which is there given of it is wholly incorrect, a circumstance I can only attribute to some accidental inadvertence. Mr. Owen says, "that the trachea of the emu is remarkable for a sudden dilatation; but, in this instance, the cartilaginous rings do not preserve their integrity at the dilated part, but are wanting posteriorly, where the tube is completed by membranes only." I have made some researches into the writings of other authors also, but have not met with any accurate description of this apparatus.

As I have lately had an opportunity of examining this appendix in the living bird, as well as in one recently dead, I shall state such facts as I have observed in the former condition, as well as the appearances I have remarked in the latter. I may first observe, that this exists both in the male and female; for some time since I dissected a male emu, and

found the opening in the trachea, but the soft parts were too much injured by decomposition to admit of an accurate examination of the sac itself. The specimen from which the following account is taken is an adult, or probably, an old female.

The cervical air-bag (fig. 1) occupies a broad and deep depression on the forepart of the neck, immediately above the sternum and furculum bone, which latter in this bird is small and imperfect. The sac is not observable either in the living or the dead bird, unless distended, when it slowly bulges forwards and laterally, and fills the depression above-mentioned; it is not, however, even then so prominent as to cause any remarkable deformity. On examining this region during life, the sac being undistended, I found the skin very moveable; it gave to the hand the sensation of great warmth, when contrasted with the surrounding parts. The entire of the trachea was very moveable to either side; but on fixing it steadily, and carrying the fingers along its forepart down to the sternum, the tube was felt a little above the latter to be flattened or depressed, but no slit or opening could be distinguished; the sac was perfectly flaccid and compressed, and the communication with the trachea was closed. This examination did not appear to cause any peculiar uneasiness in the part, or to excite any general irritation in the respiratory system. This bird, however, is very restless and timid, and very impatient under any restraint; it is also possessed of great muscular power, three or four men being required to secure it, and the attempt to do so is by no means free from danger, either to itself or to those around, as it struggles with great violence, and strikes with its powerful claws in every direction. I succeeded twice, however, to my satisfaction, in feeling this region; and I think I am warranted in concluding that the tracheal opening is usually closed, and that it may be opened at the pleasure of the animal. The plumage in this situation is thin and scanty; the feathers are chiefly of the double spe-

cies, that is, two barbs proceeding from one quill ; the barrel of the latter is small, and filled with pith, and the feathers are fine and hair-like. This, indeed, is the general character of the plumage of the struthiones.

A few days after the death of one of these birds (a female), I carefully examined the sac, larynx, and trachea, and the following is an accurate account of the several appearances. The integuments covering the air-bag differ in no respect from the general investment of the neck ; beneath the skin is a strong and red muscular lamina, expanded over its sides and forepart ; the fibres are chiefly longitudinal, but several strong fasciculi run in different directions ; the subjacent areolar tissue contains numerous nerves and vessels, especially veins. On opening the bag, the tracheal orifice (fig. 2) is seen distinct and well-defined, of the form of a long parallelogram ; the mucous membrane of the tube is continued around its free margin, is reflected over, and adheres to the anterior and lateral parts of the tube considerably beyond the edges of the opening, and then expands in all directions to line this capacious reservoir, which is sufficiently large to contain at least a quart or three pints of fluid. This membrane is soft and vascular ; numerous capillaries and large veins, with long tortuous nerves, are seen distinctly through it. The tracheal opening (fig. 4) is situated about three inches above the furculum, and in the middle line of the tube ; it is two inches and a half long, and scarcely half an inch wide, but it can be easily extended to three inches in the vertical and to three-quarters of an inch in the transverse direction ; it is produced by a deficiency in the anterior part of six rings (in the two specimens I have examined the number was the same) ; the cartilage above and that below the opening is broad and well defined ; the extremities of the six lateral cartilages are sharp, thin, and very moveable ; there is no dilatation, at least to any appreciable degree, in this part of the tube, and the rings are not all extended or continued into

the parietes of the sac, but, on the contrary, are bent towards each other of opposite sides, and can, by a little lateral pressure, be brought into contact. On the interior of the back part of the trachea, exactly opposite the opening in the median line, a remarkable prominence, or vertical keel-like projection is observed standing forward into the tube, and presenting a ridge of rounded bifid points or tubercles; when the sides of the opening are approximated, the anterior extremities of the six rings come into contact with and are supported by this posterior ridge, so that the trachea is there divided into two channels, one at either side of this middle line; and thus, when the opening into the sac is closed, the respiratory passage is maintained free and uninterrupted, while at the same time its anterior wall is well supported against any collapse into the cavity, and is also enabled to resist the weight or pressure of the external atmosphere, under the suction influence of the inspiratory efforts: this posterior keel-like projection extends for some distance on the back part of the trachea, both above and below the opening. When the trachea is relaxed in the longitudinal direction, the rings are all approximated, and those bounding the opening are a little overlapped by that above and that below it, and the apposition of the several segments is still further secured by the pressure of the superincumbent soft parts. This cervical air-bag bears no analogy to the air-cells disseminated through different parts of the bodies of birds; such are formed of cellular tissue, but this is an extension of the mucous surface, and has no communication with the air-cells, excepting through the trachea and lungs.

The TONGUE (fig. 1) is small, flat, thin, and triangular; its surface presents but few papillæ, but is studded with innumerable small points, orifices of mucous follicles; its margins are neatly fringed with five or six loose, denticulated folds on either side, some of which are a quarter of an inch in length. From the base of the tongue proceeds backwards a thick semilunar

fold of membrane, of the same colour and texture ; from its centre is a short, conical projection, analogous in its position, in front of the glottis, to an epiglottis, and capable of acting as such to a slight extent ; it is devoid of cartilage, but when the tongue is retracted, this process can cover the anterior half of the glottis. The HYOID BONE, or rather cartilage, supports the tongue by a broad basis, from the centre of which a short, strong style passes forwards in the median line ; a similar process descends in front of the thyroid cartilage, and is attached to it, and to the forepart of the trachea, by elastic ligament ; the cornua are pliant and elastic, and curved backwards in a tortuous form ; they support the pharynx and fauces, and admit of considerable expansion. The glottis, or superior larynx is well developed, and bears some resemblance to the rima in mammalia ; its aspect is obliquely upwards and backwards, and is placed, as usual in birds, on the posterior plane of the trachea, though not to the same extent ; but it is devoid of all spines, tubercles, and papillæ, nor has it the chink-like form so common in that class. The thyroid cartilage bounds the larynx in front, the cricoid behind : on the upper edge of the latter are two thin broad plates, passing forwards, from the inner side of the centre of each there is a prominent and firm fibro-mucous body, projecting inwards ; these bodies bear some analogy to arytenoid cartilages ; they nearly touch, and can easily be made to do so, whereby the opening is divided into two parts ; the anterior, small and triangular, can be covered by the epiglottis when the tongue is retracted ; the posterior is round or oval, and can only be closed by the action of the surrounding muscles pressing its sides into contact during the act of deglutition. These two portions bear a close resemblance in form to the human rima glottidis, when subdivided into two by the approximation of the long, anterior, basilar processes of the arytenoid cartilages (fig. 1)

The trachea is of considerable length, the rings are all

cartilaginous, compressible, and elastic ; they are 104 in number in the female, (I did not count them in the male specimen) ; sixty-four are above the tracheal opening, six correspond to the open portion of the tube, and there are thirty-four between this and the division into the right and left bronchi ; in each of the latter are six semicircular cartilages, and three rudimental fragments ; beyond these, the air-tubes abruptly become membranous and muscular, and no cartilages are continued into the lungs. The form of the tracheal tube is somewhat transversely elliptical, but is indented posteriorly through its whole extent ; that is, each ring is curved posteriorly, so as to be convex towards the canal, and concave towards the spine ; this general indentation is increased by the slightest pressure ; the œsophagus is closely connected to it, and when distended, during the deglutition of any large substance, would appear to derive some accommodation from this structure. This posterior indentation is much increased in depth opposite the tracheal opening, and thus accounts for the corresponding vertical prominence internally already described ; in this particular situation, the cartilages are also somewhat differently modified, as we shall notice presently. A yellowish elastic structure extends the whole length of this posterior depression on the trachea (fig. 5) ; this increases in strength inferiorly, and terminates at the division into the two bronchi ; beneath this elastic ligament, opposite the tracheal opening, and a little above and below it, short, but strong, transverse muscular bands pass across the groove, and are inserted into the cartilages at either side (fig. 5) ; these fibres, by approximating this attachment, will tend to preserve, and even protrude the keel-like projection within, and thus enable it the better to support the approximated ends of the lateral cartilages in front ; the longitudinal elastic ligamentary tissue admits of the extension of the trachea, and can restore it to its state of rest, on the subsidence of the extending force.

The tracheal cartilages present some difference in size and form in different portions of the tube ; their diameter gradually, but slightly, increases from above downwards, and a very trifling swell is observable in the region of the opening. The upper and middle rings present flattened surfaces, and their edges, above and below, are connected by elastic membrane ; those below the opening, though forming larger circles, are small, round, and weak, and have an oblique direction downwards and forwards ; this portion of the tube is very elastic ; the four or five last cartilages are deficient posteriorly, in a narrow, angular interstice, which is closed by lining membrane, weak muscular fibres, and elastic tissue ; from the last ring no internal ridge or bar proceeds, but from the angle between the bronchi the mucous membrane rises mesially in a prominent falx-like fold, which is increased or diminished in depth and tension in proportion as the trachea and bronchial tubes are shortened and contracted, or elongated and distended ; the bronchial cartilages are little more than semicircles, their extremities being somewhat thick and expanded ; the two superior present, externally and posteriorly, small projecting processes, into which some fibres from the long cervical muscles are inserted ; the posterior wall of each bronchus is musculo-membranous ; although there is no inferior larynx, yet each bronchial opening,—which is of an oval form, the long axis from before backwards, or, during life, from above downwards,—is capable of great alteration in size, figure, and tension of its lateral boundaries ; these changes can be effected by the varying degrees of inspiration and expiration, by extension and flexion of the neck, and also by the action of the tracheal muscles.

The six cartilages which are concerned in the tracheal opening, deserve particular notice ; they are peculiarly elastic, and appear composed, each, of two symmetrical portions, one on either side ; each lateral portion is crescentic (fig. 6) ; the anterior cornu, flat, thin, and very moveable, is enveloped

in mucous membrane, and engaged in the edge of the tracheal opening ; the posterior cornu meets the corresponding cornu from the other side, in the posterior indentation, and both project forwards from the posterior wall of the trachea, and present the appearance internally already noticed. These posterior cornua, from the right and left crescentic cartilages, are, in some, connected together by a narrow and thin cartilaginous structure ; in others, by a narrow line of dense cellular tissue ; so that we may regard this portion of the trachea as composed not of six cartilaginous rings, open in front, but of twelve crescentic cartilages, six on each side ; their anterior cornua either bounding the sides of the opening when this is open, or in contact, when it is closed ; their posterior cornua bent forwards, so as to form the keel-like prominence internally, which will come into contact with and support the anterior cornua when these are approximated and the orifice closed, and the tracheal canal thereby divided into two lateral tubes.

From an examination of the several parts concerned in this curious apparatus, and from observing the animal during life, I am led to infer that it possesses the voluntary power of not only expanding this air-bag, but also of retaining it in that state for an indefinite time, without any continued muscular exertion, and that it can either rapidly or slowly contract, or empty it, and perfectly close its communication with the trachea. It has been remarked that on some days it is not dilated ; on others it is frequently expanded, and as frequently contracted, in a few moments, or retained in a distended state for a considerable time ; and on some occasions it remains in that condition when the bird is at rest, or apparently asleep. When about to fill it, he raises and slightly extends the neck, and darts it a little forward ; little or no muscular exertion is apparent, and the bag swells out, most probably by an expiratory effort, the glottis being previously closed, and the muscular wall of the sac being relaxed, so as

to admit of more easy dilatation; perhaps, also, the posterior transverse muscular fibres of the trachea may, by increased contraction, tend to divericate the anterior cornua of the cartilages, whilst the extension of the neck and elongation of the trachea have separated the cartilages above and below the opening; once the bag has been filled by this expiratory effort, the glottis being closed, it may be retained in that state, even should this opening become relaxed, provided the walls of the sac do not contract, and respiration may continue without the reservoir being affected, further than that the included air may be more or less changed by the admixture of fresh air from each inspiratory current: the closure of the glottis, and an expiratory effort, then appear to be the simple agencies whereby the distension of the sac is effected.

The sac can be emptied by the contraction of its muscular covering, the distending force having ceased, and the air may be expelled by expiration, or it may be drawn into the lungs by inspiration; the elasticity of the cartilages, and the compression of the surrounding parts, will then approximate the edges of the opening, which will be supported by the internal vertical projection on the back part of the tube, and thus the orifice will become so perfectly closed, that inspiration can have no effect in drawing within it the superincumbent soft parts.

When, from surveying this curious and elaborate structure, we turn our attention to its use, and endeavour to explain the design of this anomalous arrangement, we are at once met by the fact, that although this bird is in all respects so similar to the ostrich, and to the Indian cassowary, yet in it alone is this bag developed. Were a similar structure found in all the struthiones, we should have had little hesitation in connecting it—though, no doubt, erroneously—with some of the peculiar habits and endowments of this class generally; but such not being the case, we naturally ask, is there any peculiarity of climate, or any other circumstance in the locality in

which this species is found, that will explain the necessity of it, or account for its presence, or is there any peculiar power or faculty possessed by this bird of which those allied to it are deprived? or are we to regard it as one of those examples of creative omnipotence which often displays itself in the variety of its works, without any other obvious result but the mere manifestation of that power?—a remark which appears strongly verified by many of the peculiarities of the living productions of Australia.

Dr. Knox considers that the emu has been furnished with this peculiar provision to preserve it amidst those dangers from sudden floods to which New Holland is particularly exposed. “The sandy plains of this country,” he says, “are, during a great part of the year, inundated, and become then boundless marshes; and the plains generally are exposed to sudden inundations. The rivers, moreover, running westward from the great chain of mountains, terminate in vast muddy inland marshes; the emu, forced to seek his food amidst these fens, may, when obliged to have recourse to swimming (which must often be the case), fill the muscular bag of the trachea with air, and thus convert it into a swimming bladder. It may also assist the bird in escaping from his pursuers; but on this I do not mean to insist, as this organ is wanting in the galeated cassowary and in the ostrich, both equally remarkable for speed of foot.” Dr. Knox further remarks, that when the bag has been distended by an expiratory effort, and the glottis retained in a closed state, the air may be alternately circulated between the lungs, air-cells, and tracheal bag, without the bird being necessitated to allow it to escape, in order again to perform the act of inspiration, and thus give it an additional advantage in running. This explanation appears extremely probable, and, no doubt, if the inspiratory efforts are thereby rendered less frequent, this creature may be enabled to sustain its running flight (which, in speed, is said to surpass the race-horse or the grey-hound) for a longer time,

and with less fatigue, than the quadruped or man, who are incapable of keeping up long-continued rapid progression, not so much from debility in the muscular system generally, as from a failure in the inspiratory muscles, which, under such exciting and exhausting circumstances, are called on to exert additional force, in order to maintain the due quality of the blood, as well as to regulate the current of the circulation, and which exertions, when too long continued, are speedily followed by that overwhelming and well-known, though almost indescribable, sensation denominated fatigue. It appears to me, also, that this organization may still further minister to the respiratory function, by extending the surface of the mucous membrane on which the chemico-vital changes in the blood are effected. The lining membrane of this reservoir presents not only a very extensive surface, but it is also as highly organized as that lining the trachea and bronchial tubes, with which it is continuous; numerous capillaries and tortuous nerves branch throughout its texture, and several large veins course irregularly along its wall; it is, therefore, highly probable that the same changes which are effected in the blood through the parietes of the minute pulmonary capillaries, and through the thin coats of the large veins which traverse the air-cells in the bodies of birds generally, may all take place on the lining membrane of this cervical air-bag; and that this additional respiratory agency will be supplied at that very time when the function of respiration is required in the highest degree to maintain the muscular exertion and the nervous energy which the animal evinces during its rapid excursions. This adjunct to the respiratory apparatus may even be the more necessary to this animal as a compensation for the imperfectly-developed, or almost rudimental wings, which are not only of little or no avail in locomotion, but which, from the absence of those large air-cells and blood-vessels which exist in the wings of other birds, can here in no way contribute to the respiratory function.

That this peculiar organization is connected with the vocal powers of this bird, I conceive there can be very little question ; it is with surprise I have read the remark of Meckel, that this bird has no voice. Those who have frequently visited these birds in the Zoological Gardens, must have noticed the different sounds they emit ; in fact, they have two distinct voices, just as they possess distinct organs ; the most ordinary is a harsh, disagreeable, hissing voice, not unlike that of the common goose ; this is frequently heard, as the bird follows visitors round the enclosure in expectation of food ; this voice I attribute to the structure, or organization of the superior glottis. The other, and more peculiar sound, is only occasionally emitted, probably because, while in a state of captivity, the ordinary excitements are not so frequently present ; this resembles a low, hollow sound, not unlike that caused by gently striking a large drum, or moving an empty barrel ; sometimes it is sharp, short, and sudden ; at other times it is long and muffled, like the rolling of thunder, or of a smoothly-running distant carriage ; sometimes it is soft, continued, and rather melodious ; but at others it is disagreeably interrupted by harsh and rough grunting sounds. The animal only occasionally emits this voice ; on visiting the Gardens, in hope of hearing it, I have been frequently disappointed ; on other occasions, the birds have repeated it several times. The care-taker informs me that in his morning visits to open the aviary and feed the birds, they frequently make this extraordinary noise, and which he compares to the sound of thunder. The ear detects this sound as proceeding from the upper part of the sternum, that is, from the position of the sac, and, while making it, the animal extends and alters the curve of the neck, and fills this tracheal bag ; there can be no doubt, therefore, that this voice is connected, in part, with the inferior glottis, or the two narrow bronchial openings, and, in part, if not essentially, with this peculiar appendix ; there is nothing in the superior larynx, or in the inferior, alone, that

can account for it, whereas the great capacity of this reservoir, its free communication with the trachea, immediately above the narrow bronchial aperture, its sudden distension, and as sudden contraction, or the alternate partial action and relaxation of the distending and compressing agencies, together with the free and elastic vibrating borders of the tracheal opening, the resisting wall behind, and the long and softly-resonant tube, leading upwards, may, I think, satisfactorily account for these peculiar vocal phenomena. What may have been the design of imparting to this being this peculiar endowment, it would be as vain to speculate upon as to attempt to account for the infinite variety of voice that prevails throughout the animal world; that it is voluntary I have no doubt, and may be exercised either for sexual attraction or social union, or as indicative of nervous emotion, the result of anger, terror, or alarm.

This remarkable air-bag is not only peculiar to this animal, but there is nothing exactly analogous to it in any other member of the class Aves. In the trachea of several water birds there have been long observed peculiar swellings, or dilatations of the tube, in the structure of which the entire of a certain number of rings are engaged, but there is no distinct sac or bag. The laryngeal or tracheal sac in the chameleon, bears, as Dr. Knox has remarked, some remote analogy to it; the laryngeal sacs in certain of the quadrupeds, and even the ventricles in the human larynx, and the sacculi laryngis, which lead from each upwards and forwards, may be regarded as rudimental conditions of the same structure.

EXPLANATION OF THE PLATE.

Fig. 1.—Superior glottis, tongue fimbriated.

Fig. 2.—Front view of the tracheal sac; a few feathers remain.

Fig. 3.—Sac laid open, and drawn over to the right side: *a*, opening in the trachea: *b*, sharp, thin extremities of the six

rings : *c*, prominence on the back of the trachea : *d*, section of the cutaneous covering ; *e*, of the muscular ; *f*, the lining mucous membrane, extending over the front and outside of the rings, and then continued round the edges of the opening into the trachea.

Fig. 4.—Section of the trachea : *a, b, c*, as in last figure.

Fig. 5.—Posterior view of the sac : *a*, indentation on the trachea corresponding to the internal ridge in figs. 3 and 4 ; *b*, longitudinal elastic ligament, dissected off, and drawn to one side ; *c*, transverse muscular fasciculi, attached to the convexities of the cartilages on either side, raised on a small twig.

Fig. 6.—Horizontal view of three tracheal cartilages : *a*, from the upper portion ; *c*, from the lower ; *b*, corresponds to the opening, shews two semicircular cartilages, their posterior cornua projecting forwards into the tube, and ending in round and slightly bifid points ; *d d*, mucous membrane of the trachea and sac.